The Huygens Probe Gas Chromatograph Mass Spectrometer experiment, results and lessons learned

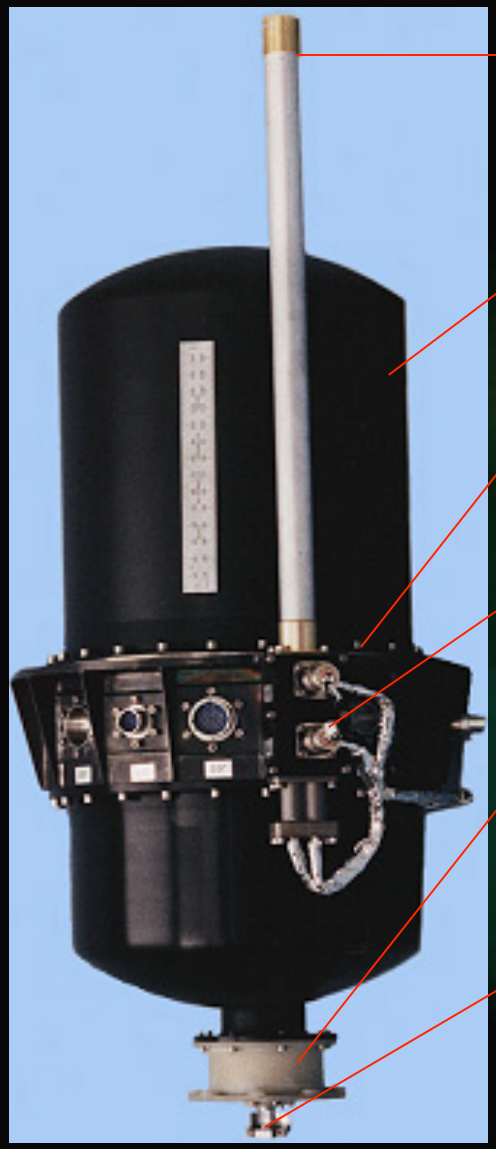
IPPW # 5, Bordeaux, France

Hasso B. Niemann, Sushil Atreya, Jaime Demick-Montelara,

Wayne Kasprzak,Tobias Owen, Stanley Way

and the GCMS Team

The Instrument



Exhaust Tube

Pressurized Housing

Mounting Flange

Outlet Break off

Thermal Inlet Isolator

Inlet Break off

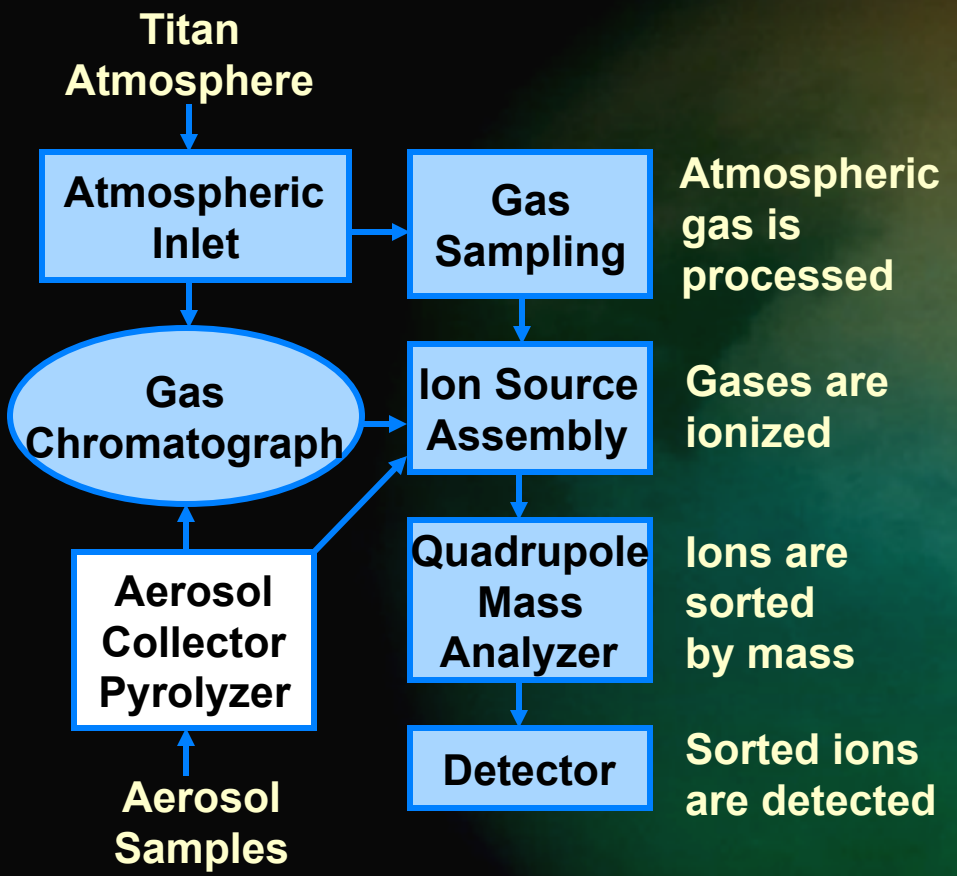
Prom Board

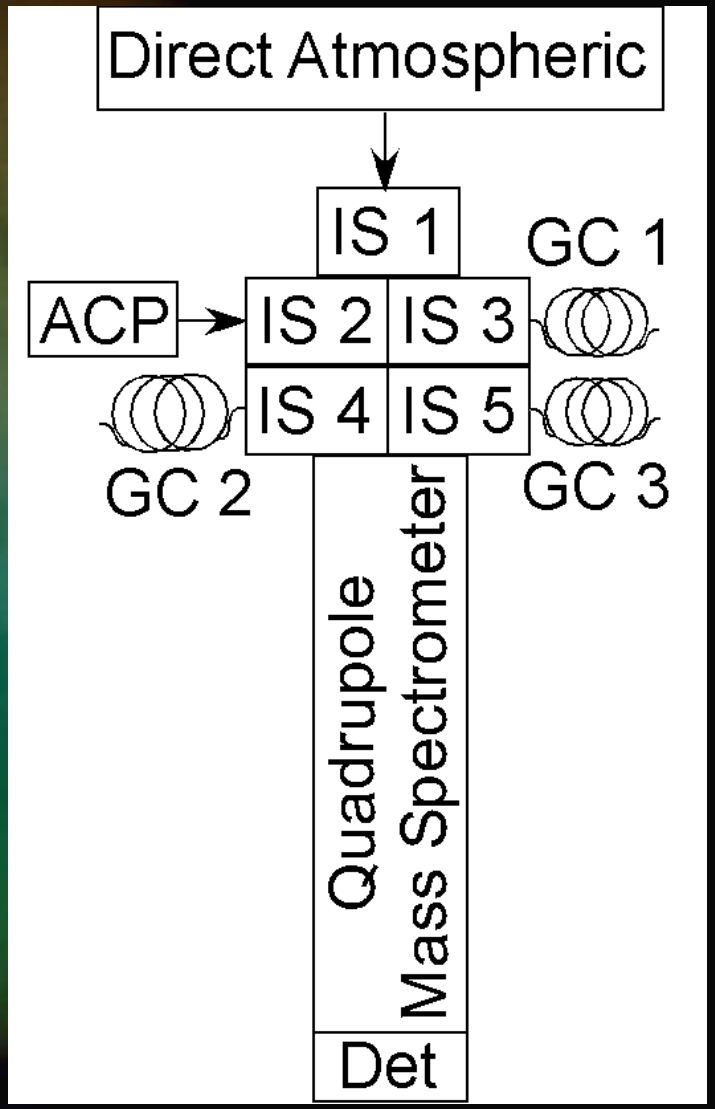
Electrical Connectors

GC Columns

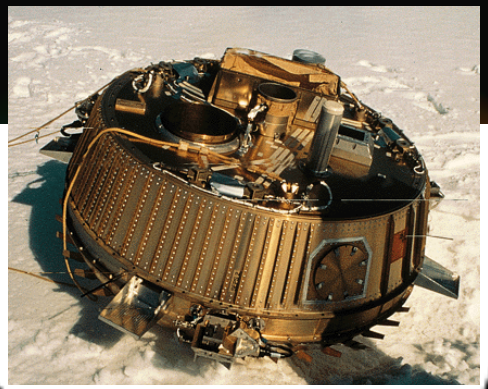
Ion Pump HV Supplies

Operating Principle

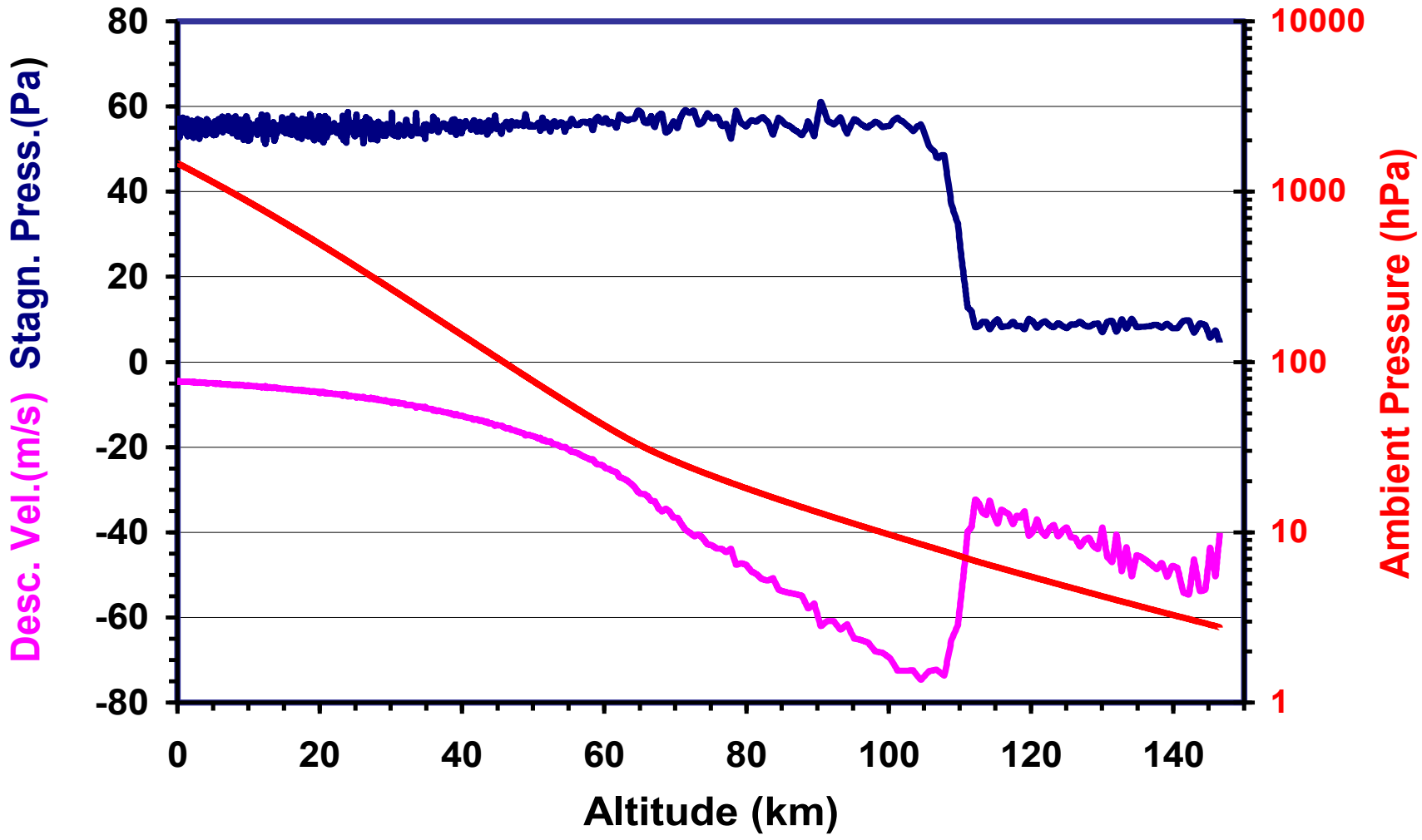




Atmosphere Inlet and Outlet Locations



Huygens Probe Descent



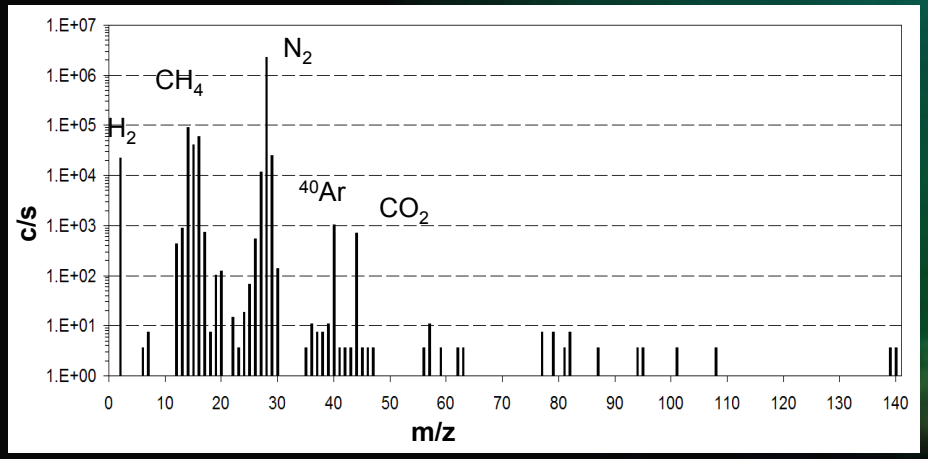
Organics in the Atmosphere

Methane was confirmed to be the second most abundant constituent in the atmosphere with nearly constant mole fraction of 1.4% from 140km altitude to the troposphere at about 35km altitude. It increased monotonically to 4.7% at 8km.

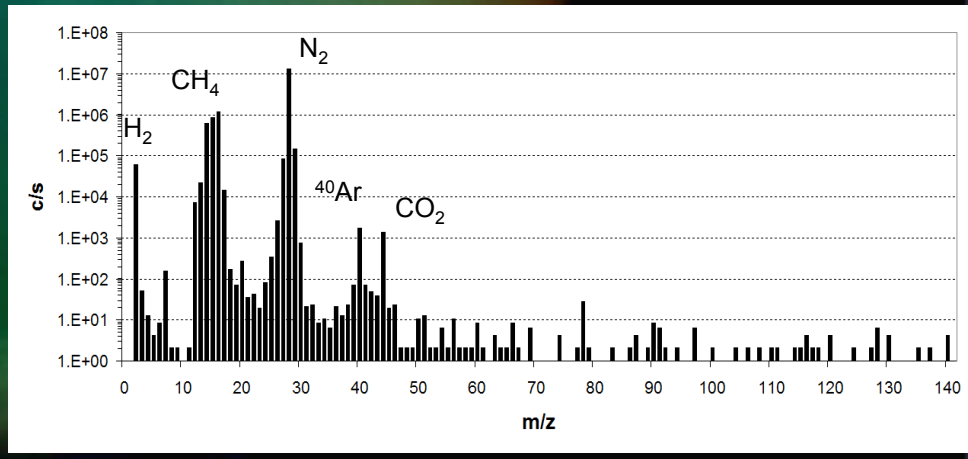
Low abundance of volatile organics in the atmosphere.

The organic chemistry seems concentrated in the aerosol particles.

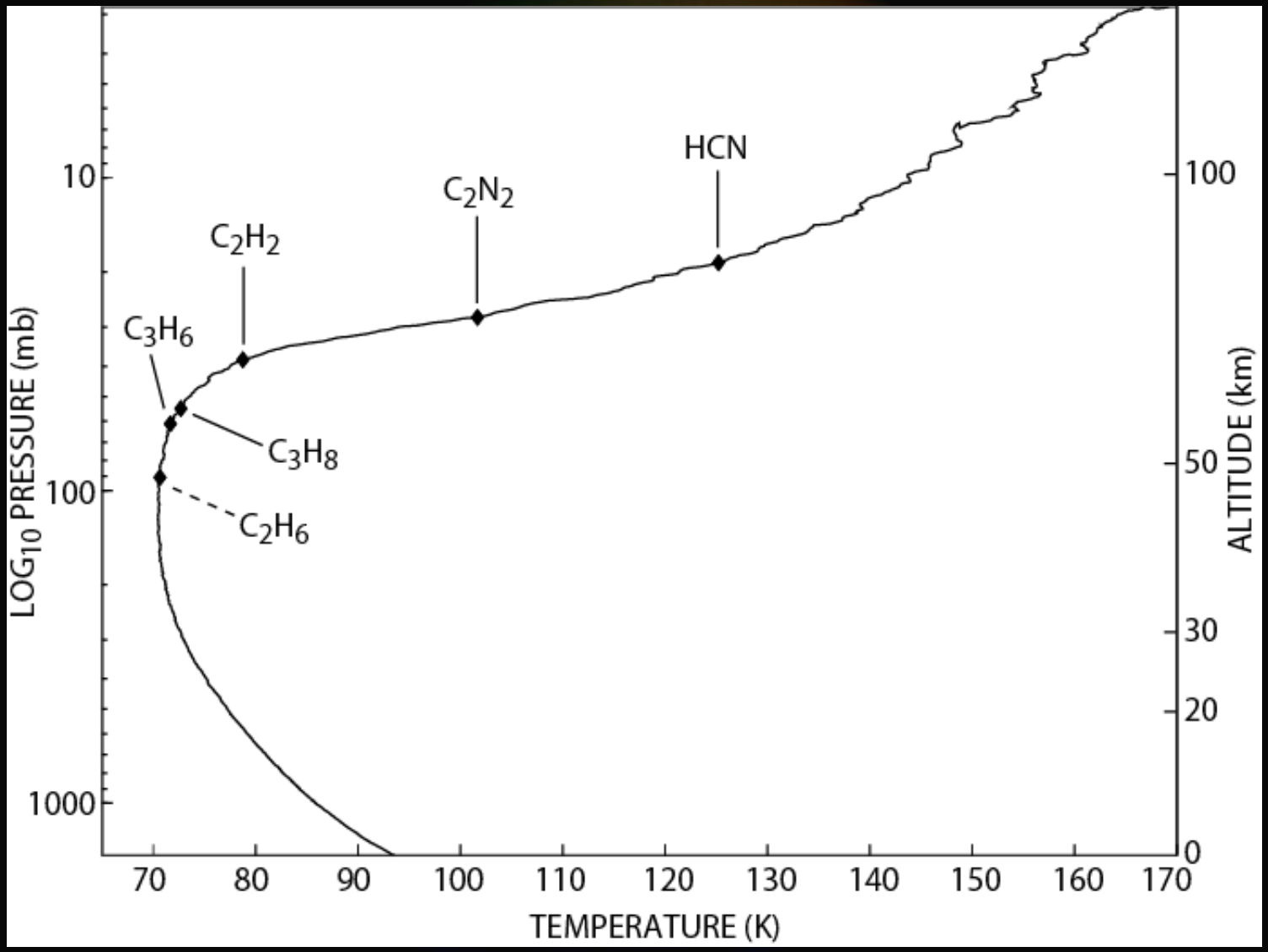
Averaged Spectrum (146-140 km)



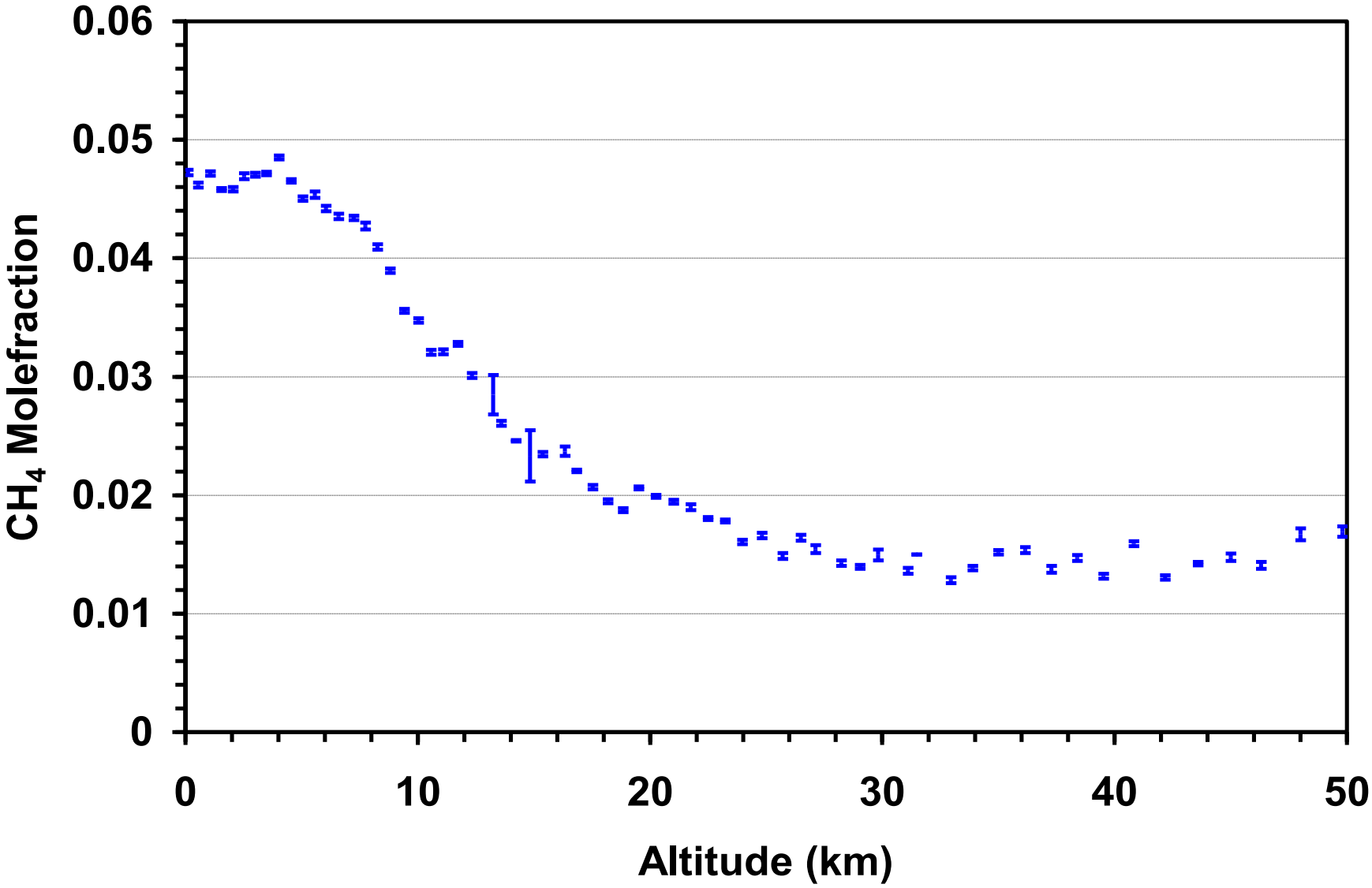
Averaged Spectrum (10-5 km)



Hydrocarbon and nitrile condensation



Methane mole fraction

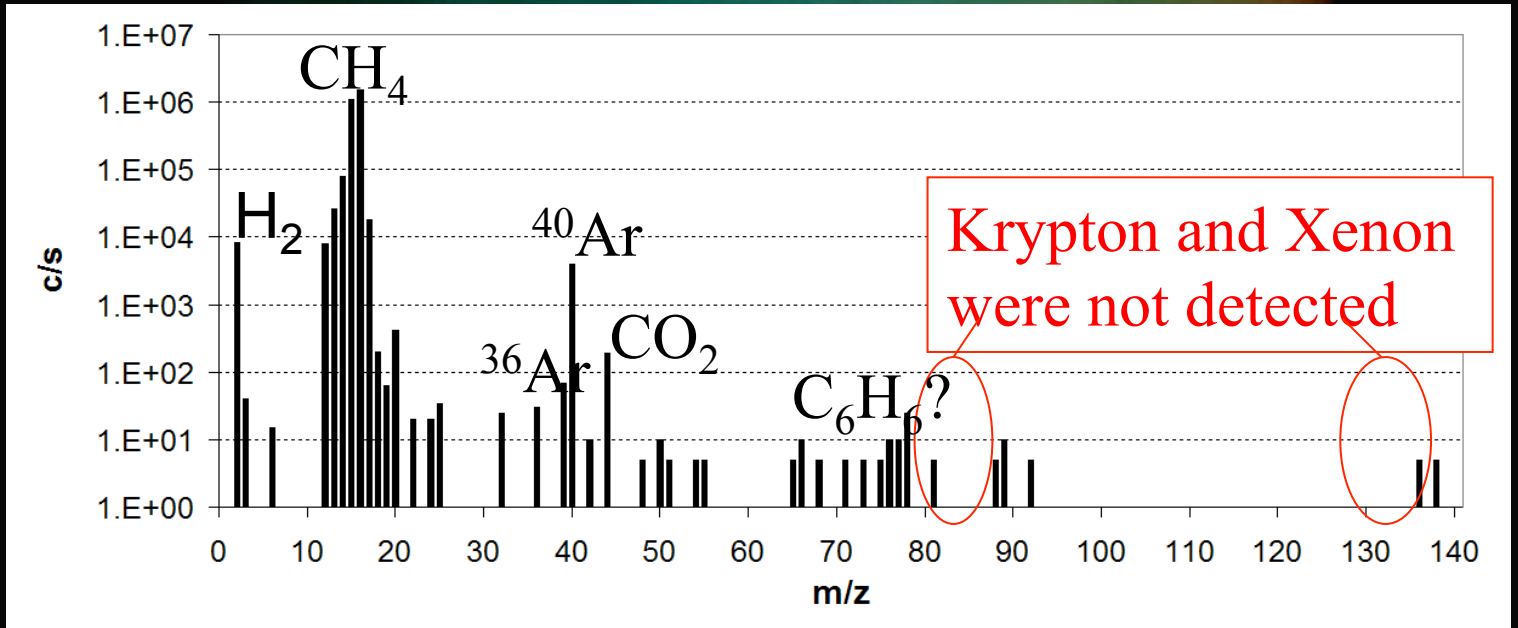


Noble Gases

Radiogenic argon, ^{40}Ar, a decay product of potassium, ^{40}K, is the most abundant noble gas in the atmosphere; mole fraction $(3.3\pm0.1)\times10^{-5}$. Outgassing of volatiles from the rocky interior.

Primordial argon ^{36}Ar, was detected in the Rare Gas Cell; mole fraction (2.2±.5)x10-7.

Mole fractions of krypton and xenon are below 10 ppb



Isotope ratios

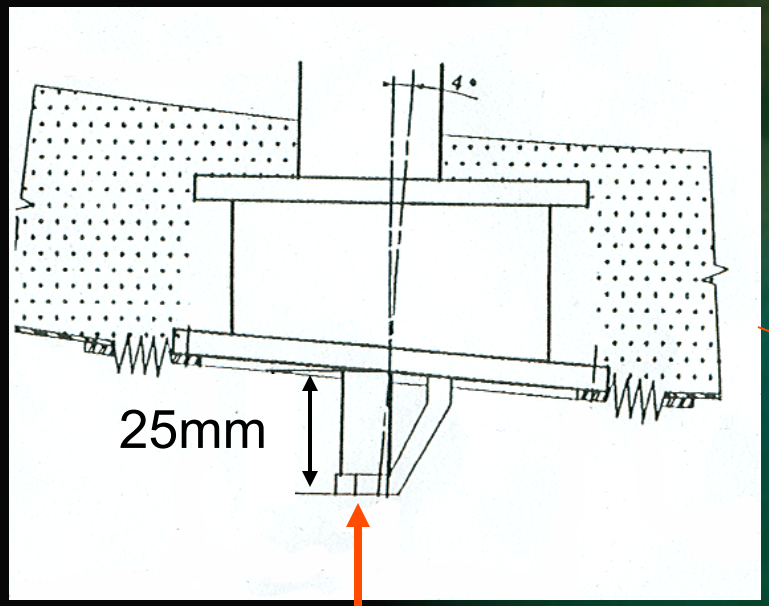
Nitrogen, $^{14}N/^{15}N$ = 183; from $^{14}N^{14}N$ and $^{14}N^{15}N$.
Terrestrial value = 273; Jupiter value = 435
Low value is result of escape, suggests that the atmosphere was ~ 5 times more dense than it is now.

Carbon, $^{12}C/^{13}C$ = 82.3; from $^{12}CH_4$ and $^{13}CH_4$.
Pee Dee Belemnite value = 89.9;
Biological values ~ 92-96;

- Methane in the atmosphere is continuously or episodically replenished from the interior.
- Biologically derived contribution, if any, was not detectable.
- Non biologic source of methane on Titan?

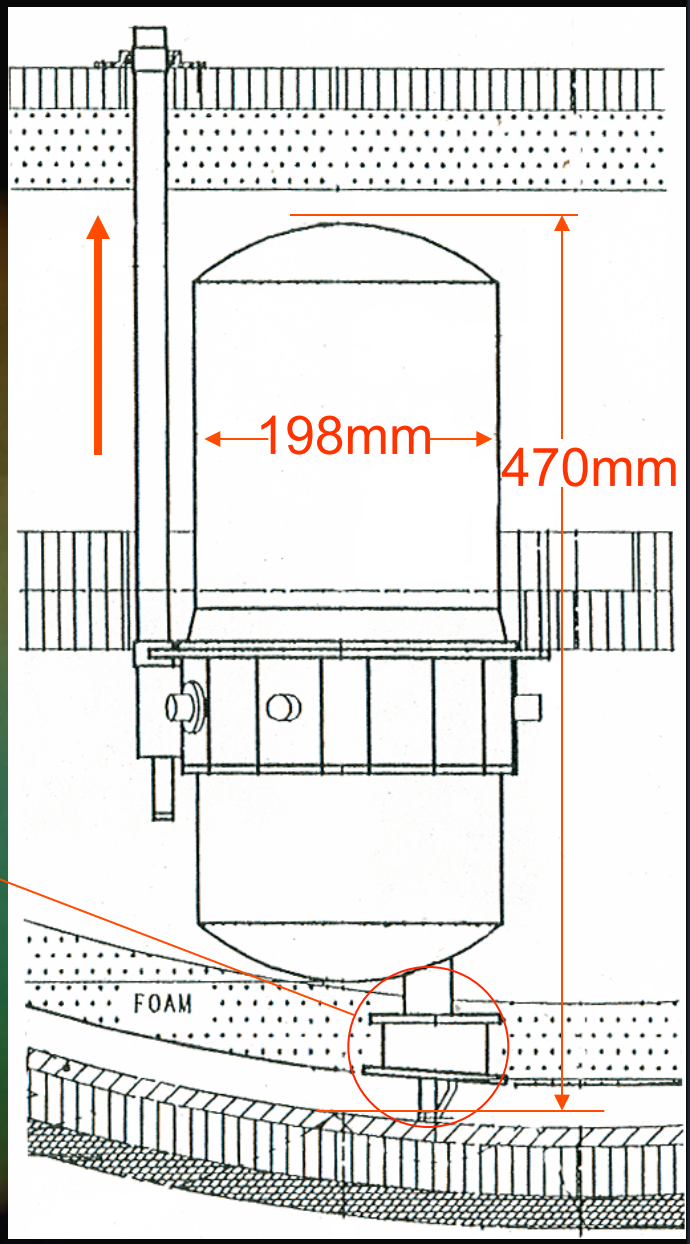
Hydrogen, D/H = 2.3×10^{-4}; from DH and H_2.
Terrestrial value = 1.6×10^{-4};
Oort-cloud comet values in H_2O ~ 3.2x10-4;

Heated Sample Inlet



Atmosphere Inlet

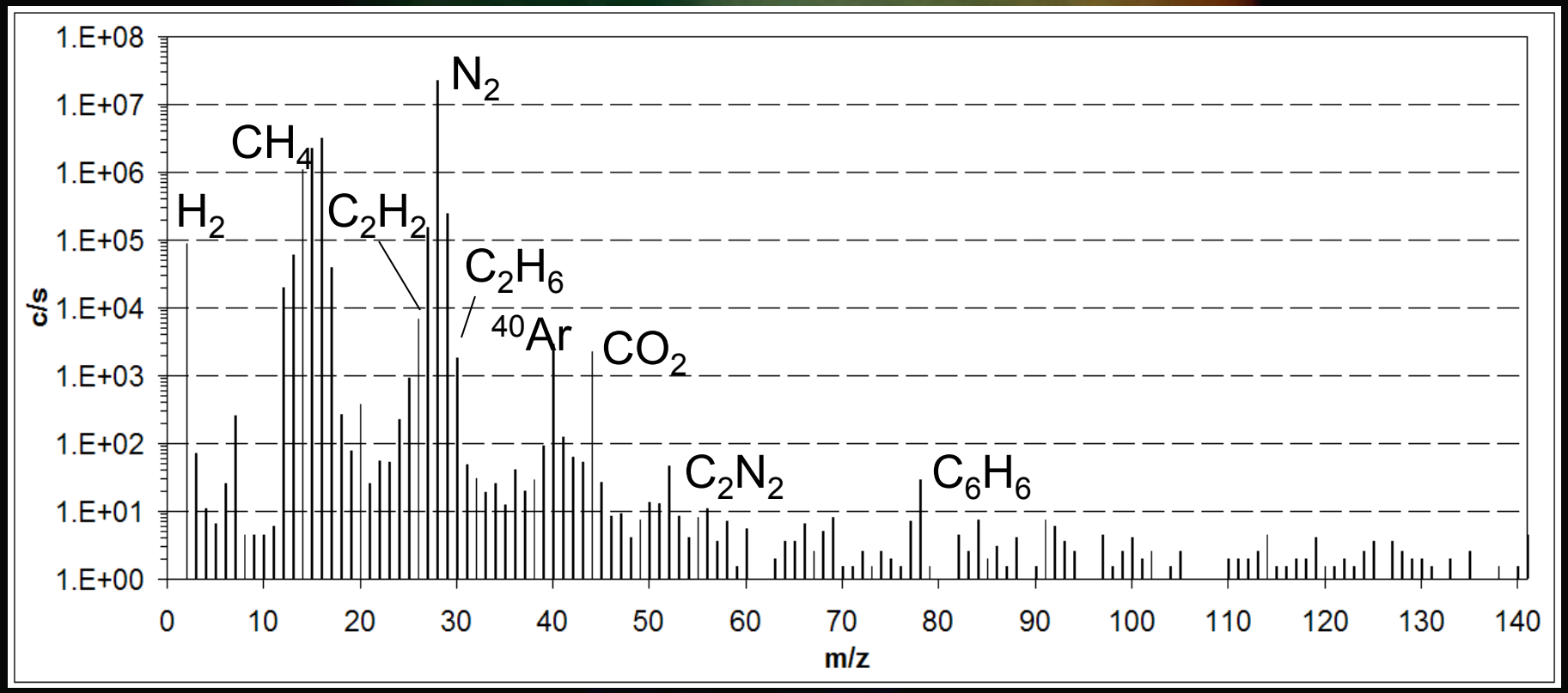
Atmosphere Outlet



Front Shield

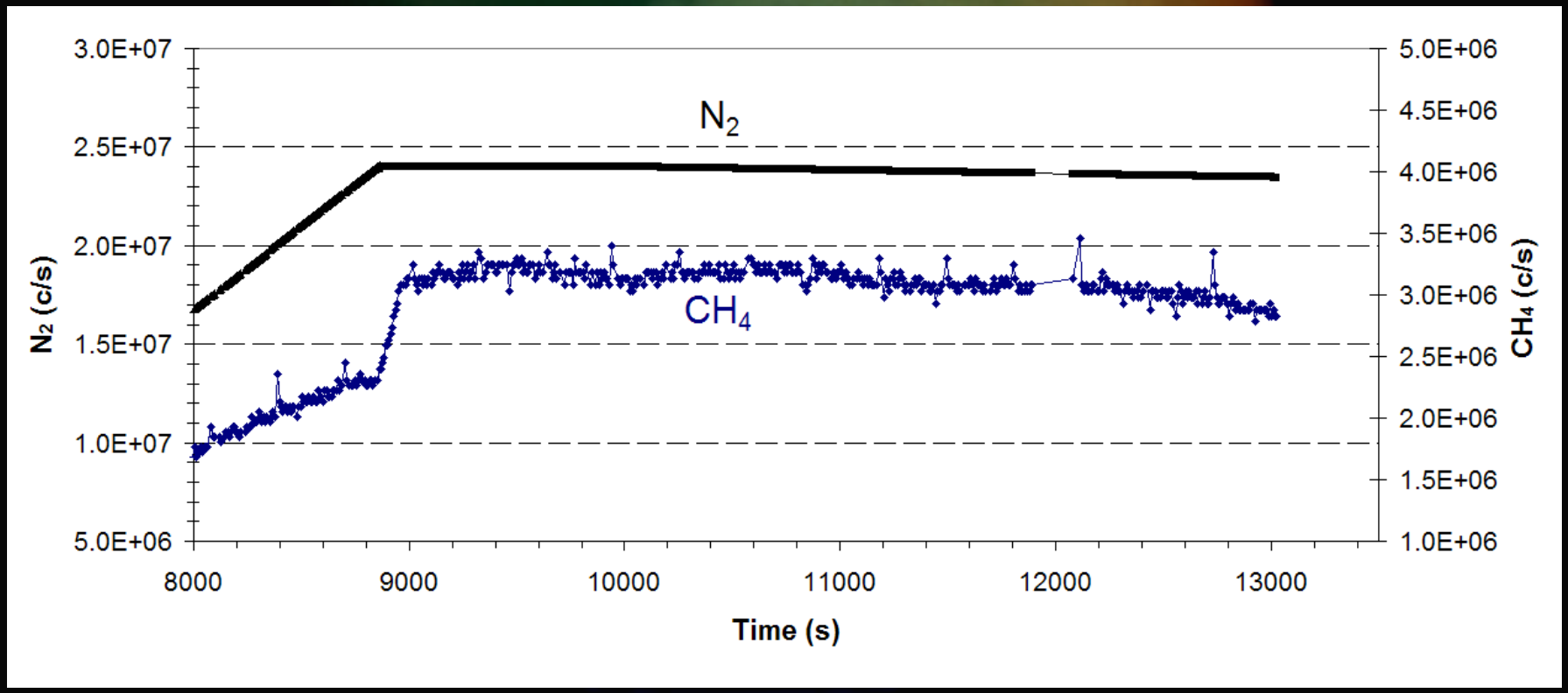
Surface Observations

Detection of various organic compounds on the surface:
Ethane, acetylene, cyanogen, benzene and in addition carbon dioxide.



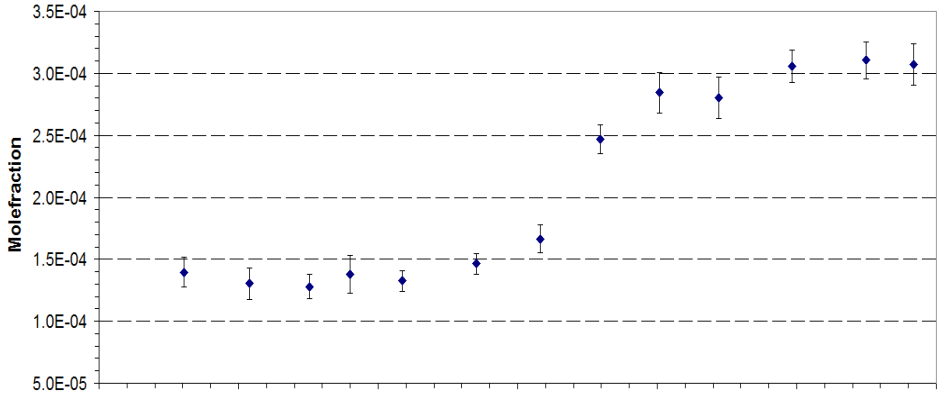
Surface Observations

Methane evaporated from the surface after warming from the heated sample inlet as observed by an increase of the methane signal after impact. A moist area with liquid methane in the near sub-surface is indicated.

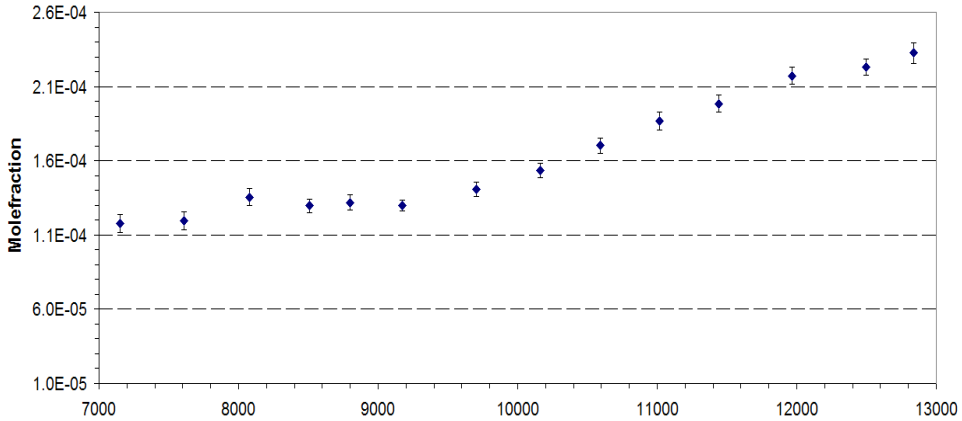


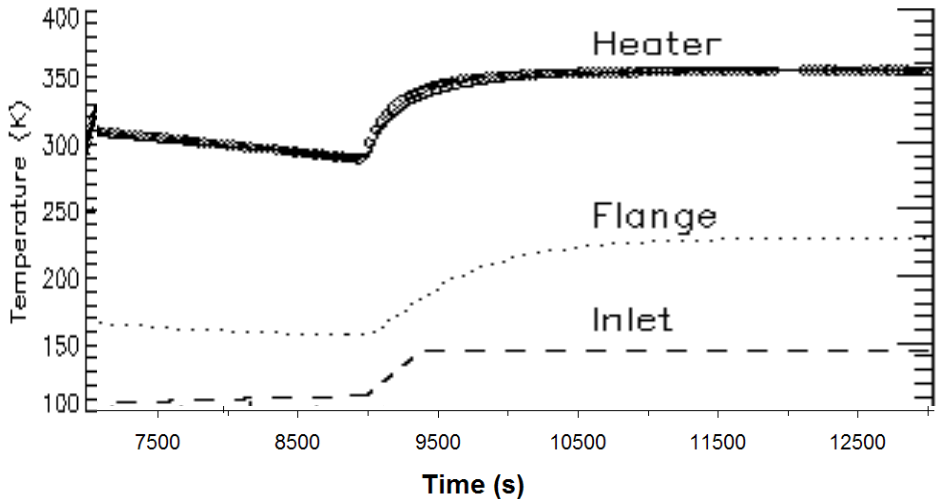
Surface Response of C_2H_2 and C_2H_6

C_2H_6



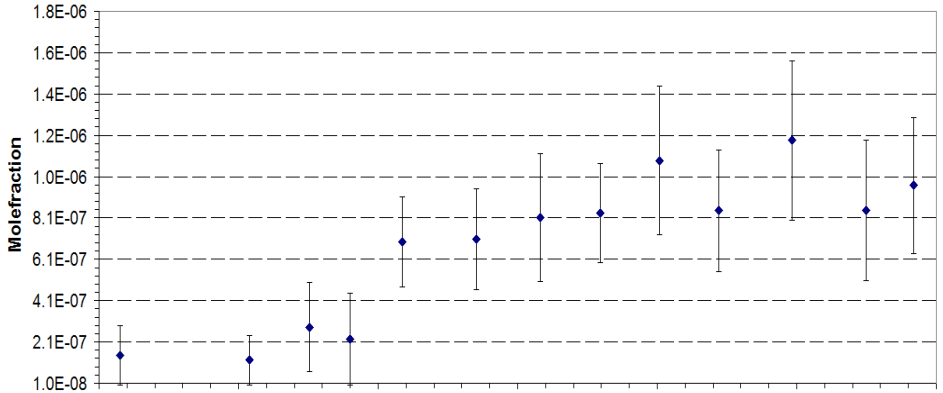
C_2H_2



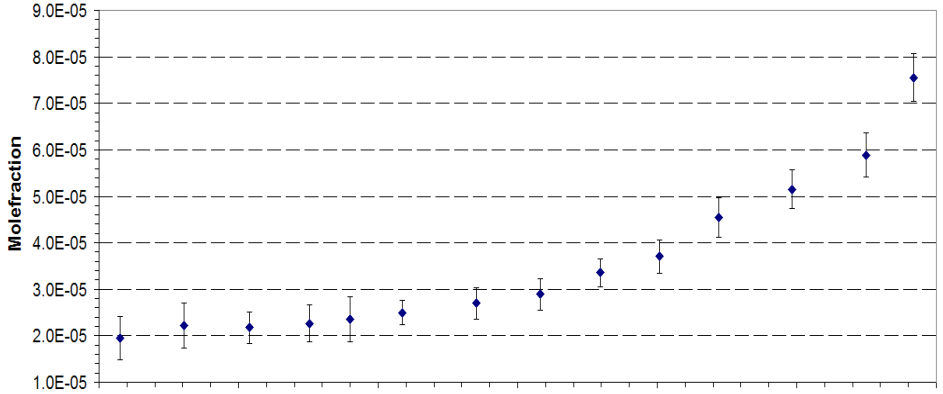


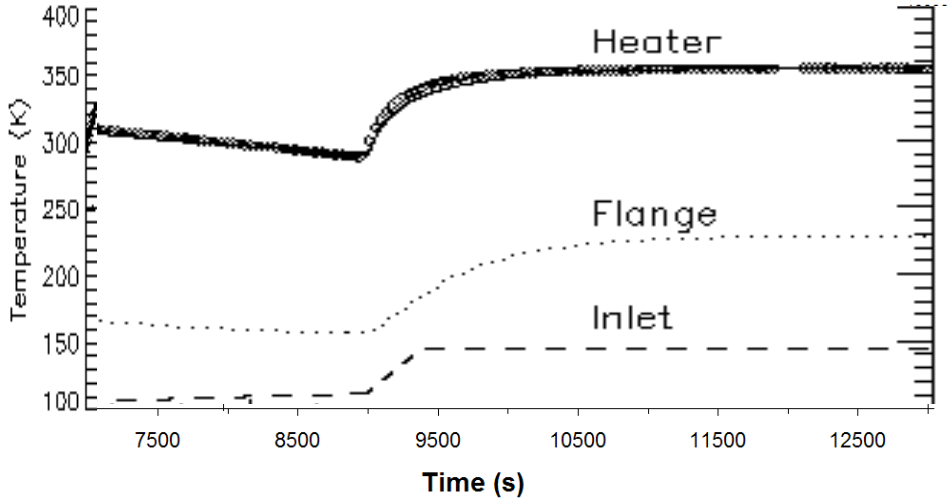
Surface Response of C_2N_2, C_4H_4 and CO_2

$C_2N_2 + C_4H_4$



CO_2





Summary

- Increase in methane mole fraction near and at surface is evidence of a humid atmosphere and liquid methane in near sub-surface
- Primordial noble gases in low concentration- upper limit for ^{36}Ar is $3x10^{-7}$; Kr, Xe is $<10^{-8}$
- As predicted, organic molecules were not detected in large quantities in the atmosphere
- Vapors of organic molecules were detected after the probe landed and the surface was heated by the probe

Lessons Learned

- Successful international collaboration led to a more than linear increase in scientific results and world wide popularity
- The mission design was appropriate
- In exploratory missions the scope of scientific experiments needs to be broader than the primary mission goal to account for the unexpected